Video Article

Multifocal Electroretinograms

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Abstract

A limitation of traditional full-field electroretinograms (ERG) for the diagnosis of retinopathy is lack of sensitivity. Generally, ERG results are normal unless more than approximately 20% of the retina is affected. In practical terms, a patient might be legally blind as a result of macular degeneration or other scotomas and still appear normal, according to traditional full field ERG. An important development in ERGs is the multifocal ERG (mfERG). Erich Sutter adapted the mathematical sequences called binary m-sequences enabling the isolation from a single electrical signal an electroretinogram representing less than each square millimeter of retina in response to a visual stimulus[1].

Results that are generated by mfERG appear similar to those generated by flash ERG. In contrast to flash ERG, which best generates data appropriate for whole-eye disorders. The basic mfERG result is based on the calculated mathematical average of an approximation of the positive deflection component of traditional ERG response, known as the b-wave[1]. Multifocal ERG programs measure electrical activity from more than a hundred retinal areas per eye, in a few minutes. The enhanced spatial resolution enables scotomas and retinal dysfunction to be mapped and quantified.

In the protocol below, we describe the recording of mfERGs using a bipolar speculum contact lens.

Components of mfERG systems vary between manufacturers. For the presentation of visible stimulus, some suitable CRT monitors are available but most systems have adopted the use of flat-panel liquid crystal displays (LCD). The visual stimuli depicted here, were produced by a LCD microdisplay subtending 35 - 40 degrees horizontally and 30 - 35 degrees vertically of visual field, and calibrated to produce multifocal flash intensities of 2.7 cd s m^{-2}. Amplification was 50K. Lower and upper bandpass limits were 10 and 300 Hz. The software packages used were VERIS versions 5 and 6.

Video Link

The video component of this article can be found at http://www.jove.com/video/3176/

Protocol

1. Protocol text

Select a room with little electrical interference. A sink is convenient to wash your hands and to clean electrodes. An internet connection is also preferable to share data and for manufacturer of your system to update software or help solve problems.

1. Organize your dilating drops, balanced salt solution, topical anesthetic and cleaning products so that they are readily accessible.
2. Always place subjects in the same position and use the same room lighting for every subject.
3. After introducing yourself and the procedure, dilate the subject's eyes. Only mydriatic dilation is necessary. Once eyes dilate to about 7 mm testing can begin.
4. There are several types of recording electrodes. Popular electrodes include the ERG Jet, DTL silver wire, gold foil and speculum contact lens. If using reusable electrodes follow the manufacturer's recommendations for sterilization.
5. The convention is for recording electrode touching cornea or sclera to be positive pole, which produces signal with b-wave up. If using a monopolar recording electrode choose a location on head for the negative pole such as forehead, mastoid or earlobe. Ground electrode may be placed any location on body.
6. Clean the skin electrode locations well with alcohol and/or a skin preparation product.
7. If the recording electrode contacts the eye numb the eye with several drops of a topical anesthetic. If using contact lens or speculum contacts be very careful not to scratch the cornea.
8. If your mfERG system displays stimulus on video monitor place all subjects same distance from stimulus monitor. Make testing situation the same for every subject.
9. Pay attention that the subject is comfortable and emphasize importance of maintaining fixation and being relaxed. Choose fixation target that subject can maintain fixation. Verbally coach patients during testing to maintain fixation and stay relaxed.
10. Multifocal electroretinograms are useful to diagnose and quantify progress of most retinal diseases, ocular trauma, and retinal drug toxicity.
11. Back up your data at the end of each recording session in addition to saving in system's computer memory.
12. I recommend one consults the ISCEV mfERG recording procedure guidelines[2] and that all procedures including research subjects be approved by an Institutional Review Board.

2. Representative Results

An example of an mfERG measurement taken from a patient with significant upper left visual field loss is shown in figure 1 superimposed onto the Humphrey 24-2 visual field.

Figure 2 shows a color scale transformation for a patient with pockets of retinal toxicity between 5 and 15 degrees away from the fovea. This result is consistent with Plaquenil and chloropromazine toxicity [3, 4] which usually begins with small areas of a few square millimeters affected in region 5-15 degrees from fovea. By contrast, Stargardt's disease and cone dystrophies show conspicuous reduction in mfERGs in the central macular, where cones dominate. This result illustrates the power of mfERG in differential diagnosis. Birdshot chorioretinopathy (Figure 3), is an uncommon retinal disorder that is peculiar in that the first electrophysiological anomaly is a slowing of cone physiological response. The progression of this slowing can be followed using mfERG, as the effect progresses from a small area in the nasal retina region to the complete coverage of the retina (Figure 4).

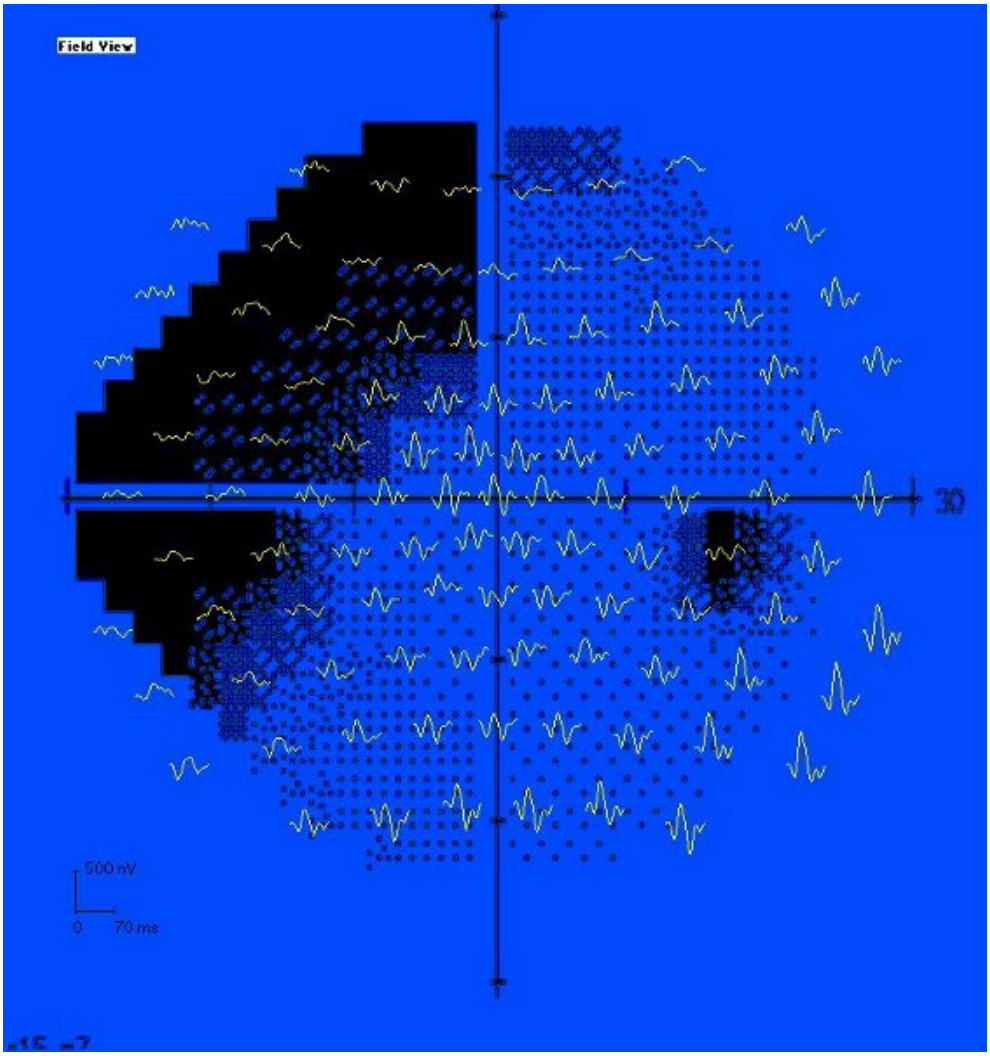

Figure 1. Multifocal ERGs superimposed on Humphrey 24-2 visual field showing agreement with field loss.

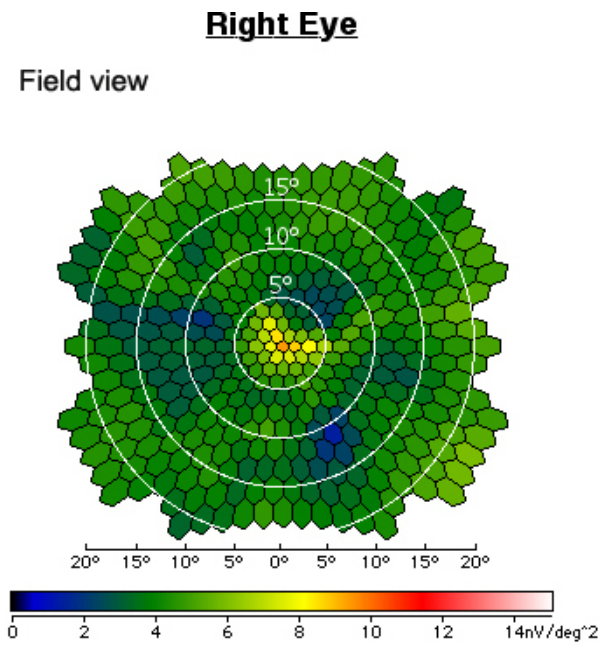

Figure 2. Color scale transformation mfERGs "amplitudes" in patient showing early pockets of retinal toxicity 5-15 degrees from fovea.

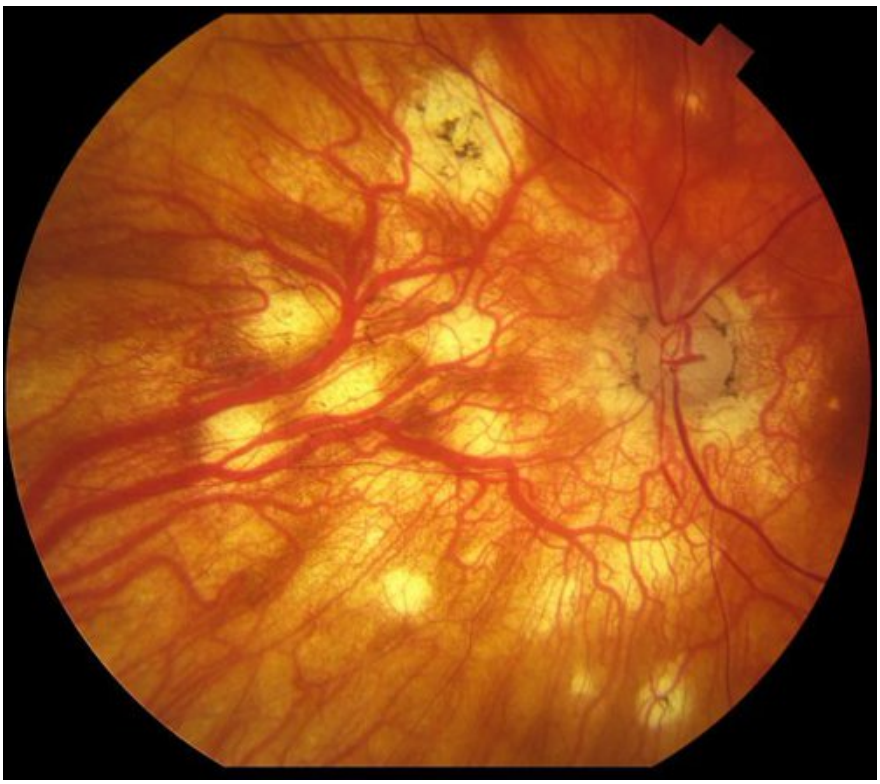

Figure 3. Fundus photo of nasal retina left eye of patient with birdshot chorioretinopathy.

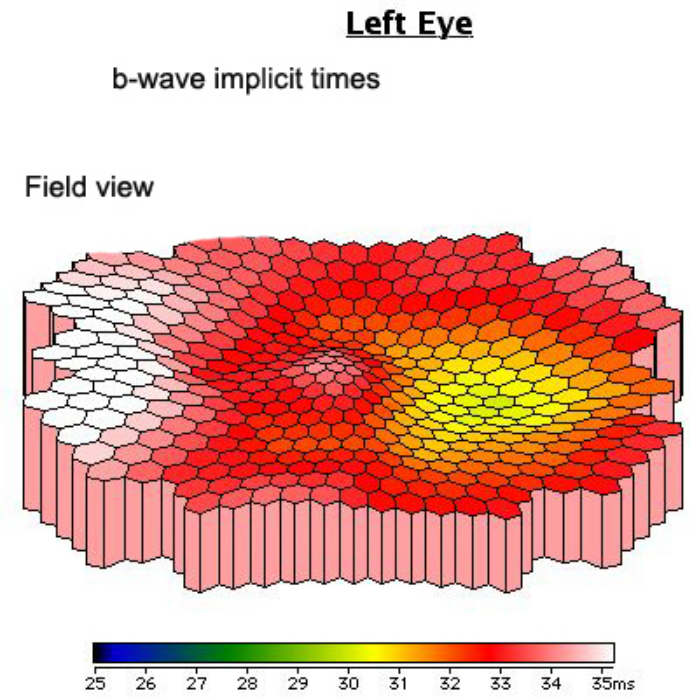

Figure 4. Color transformation of "b-wave" implicit times of left eye of patient with birdshot chorioretinopathy showing slow times.

Discussion

Traditionally, full-field and single point ERGs, which record from a limited area of the retina, have been used to diagnose and follow the progression of retinal disorders. A limitation of this approach is that these techniques are insensitive unless at least 20% of the retina is affected. Retinal trauma producing field defects produce abnormal mfERGs, consistent with visual field loss [5]. In this way, multifocal ERG testing has opened new dimensions in diagnosis and progression of retinal disorders.

When interpreting mfERG results, it is important to view both the 2D individual wave tracings and the 3D color representations. Simultaneously reviewing the complementary presentations of the data often lends greater insight as different effects can be more clearly seen in the different representations.

Examples of further methods and developments in mfERG signal analyses can be found in references [1, 2, 6, 7, 8].

It is important to remember that the mfERG procedure records a large multi-dimensional data set and to resist the temptation to rely purely on the b-wave approximation. For example, some retinal diseases affect the implicit response times of the photoreceptors at varying stages of progression, depending on the type of disease. Most manufacturers provide specialty protocols or a number of analysis and recording approaches and there are many potential benefits to taking a flexible approach to protocol selection.

Multifocal ERG can also be used to separate retinal disease from neurological-related eye disorders. A good example is the comparison of mfERGs results to optical coherence tomography (OCT) measurements in order to correlate functional (mfERG) to morphological (CT) changes [1, 9].

Disclosures

No conflicts of interest declared.

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